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(12) # EUROPEAN PATENT SPECIFICATION

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(54) **Compressor wheel assembly.**

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US-A-2 465 625

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Description

This invention relates generally to centrifugal compressor wheels or impellers of the general type used commonly with turbochargers, superchargers, and the like. More specifically, this invention relates to an improved centrifugal compressor wheel and its method of manufacture, wherein the compressor wheel is designed for substantially prolonged fatigue life.

Centrifugal compressor wheels in general are well known for use in turbochargers, superchargers, and the like wherein the wheel comprises an array of aerodynamically contoured impeller blades supported by a central hub section which is in turn mounted on a rotatable shaft for rotation therewith. In the context of a turbocharger, by way of example, the hub section conveniently includes a central axial bore through which the shaft extends, and a nut is fastened over the shaft at the nose end of the wheel to hold the hub section tightly against a shaft shoulder or other diametrically enlarged structure rotatable with the shaft. The shaft thereby rotatably drives the compressor wheel in a direction such that the contoured blades axially draw in air and discharge that air radially outwardly at an elevated pressure level into a volute-shaped chamber of a compressor housing. The pressurized air is then supplied from the chamber to the air intake manifold of a combustion engine for admixture and combustion with fuel, all in a well-known manner.

In recent years, improvements in compressor technology and design have resulted in progressive increases in compressor efficiencies and flow ranges, together with more rapid transient response characteristics. For example, compressor wheels for turbochargers are well known wherein the impeller blades exhibit compound and highly complex curvatures designed for optimum operational efficiency and flow range. Such complex blade shape is most advantageously and economically obtained by a casting process wherein the wheel hub section and blades are integrally formed desirably from a lightweight material, such as aluminum or aluminum alloy chosen for its relatively low rotational inertia for achieving the further advantage of rapid accelerative response during transient operating conditions.

Cast compressor wheels of this general type, however, have a relatively short, finite fatigue life resulting in undesired incidence of fatigue failure during operation. More specifically, when the compressor wheel is rotated at operating speeds up to 100,000 rpm or more, the cast aluminum material is subjected to relatively high tensile loading in a radial direction particularly in the hub region of the wheel which must support the radial wheel mass. The impact of this tensile loading can be especially severe when the wheel is operated in a relatively high-speed, rapid speed cycle environment, such as, for example, turbochargers used with earth-moving equipment, front-end loaders, back hoes, and the like. Unfortunately, the hub region of the cast wheel includes a major void, namely, the central bore for reception of the rotatable shaft, wherein this central bore acts as a major stress riser rendering the wheel highly susceptible to fatigue failure in the hub region. This fatigue problem is compounded by the presence of metallurgical imperfections such, as dross, voids, and inclusions, which occur inherently as part of the casting process and which tend to congregate in the hub region of the wheel.

It is known that fatigue failures in compressor wheels can be significantly reduced, or alternately stated, the fatigue life of the compressor wheel can be substantially prolonged by forming the wheel from a noncast material, such as a forged or wrought aluminium or aluminium alloy, thereby avoiding the internal imperfections inherently resulting from a casting process. However, such noncast compressor wheels have not been practical from a cost or manufacturing standpoint primarily due to the complex machining requirements to form the impeller blades with the desired aerodynamic contours.

British Patent Specification No. 2091380 (MTU) discloses a turbocharger in which each of the turbine and compressor rotors is in the form of a solid disc. One disc has a threaded bolt frictionally welded to its back face while the other has a bearing support tube friction welded at its back face and having an internal thread for cooperation with the thread of the bolt on the first rotor.

According to the present invention an attachment member mounted on the hub of a compressor rotor comprises a cylindrical thrust spacer sleeve having at least one annular groove formed in its outer surface for a sealing ring for sealing the rotating parts in an opening in a wall separating a compressor housing from a bearing housing and is also characterised in that the thrust spacer sleeve cooperates with a shoulder constituting a component of a thrust bearing for the rotating parts.

This design enables the attachment member to fulfil three functions namely the function of mounting the compressor rotor on the shaft without having to have a bore in the rotor; the function of providing the necessary lubricant seal between the rotating parts and a hole in a wall separating the compressor housing from the bearing housing; and the function of constituting a component of a thrust bearing for the rotating parts.

Thus the attachment member may be made of the appropriate material with suitable hardening or other treatment prior to being attached to the compressor wheel hub for fulfilling all these load bearing functions.

The attachment member conveniently comprises an internally threaded steel sleeve with a wear resistant outer surface which has been hardened by heat treatment.

The compressor wheel is conveniently cast and preferably with the impeller blades integral with

the hub. Conveniently it is cast from aluminium or an aluminium alloy or other light material whereas the attachment member is conveniently of steel or other wear resistant material which may be hardened on bearing surfaces.

The impeller blades may have a forward blade rake generally adjacent the wheel nose, and at least some backward curvature generally adjacent the periphery of a wheel back plate disc. In one embodiment of the invention, the wheel nose has an axially presented generally polygonal profile for engagement by a spanner.

The invention may be carried into practice in various ways, and one embodiment will now be described by way of example with reference to the accompanying drawings in which:

FIGURE 1 is a perspective view illustrating a centrifugal compressor wheel for use with a turbocharger or the like;

FIGURE 2 is an exploded perspective view illustrating an initial step in the formation of an improved compressor wheel assembly embodying the novel features of the invention;

FIGURE 3 is an enlarged vertical section of the compressor wheel assembly in completed form ready for installation into a turbocharger or the like; and

FIGURE 4 is a fragmented vertical section illustrating the compressor wheel assembly of FIGURE 3 installed into a turbocharger.

As shown in the exemplary drawings, a compressor wheel assembly referred to generally by the reference numeral 10 is provided for use as a centrifugal impeller in a turbocharger, a supercharger, or the like. The compressor wheel assembly 10 comprises a boreless compressor wheel 12 having a hub 14 integrally supporting a circumferential array of contoured centrifugal impeller blades 16, wherein the hub is attached to a cylindrical thrust spacer sleeve 18 adapted for facilitated connection to the rotatable shaft 20 of a turbocharger or the like.

The compressor wheel assembly 10 of this invention provides substantial improvements in wheel fatigue life over conventional centrifugal compressor wheels of the type used in turbochargers, superchargers, and the like, without sacrificing efficiency and flow range in accordance with a preferred aerodynamic contouring of the impeller blades 16. This blade contouring includes complex and compound blade curvatures which effectively prohibit manufacture of the blades by any means other than a casting process, such as a rubber pattern or lost wax process. Alternately stated, this complex blade contouring renders other forming techniques, such as forging, machining, and the like, impossible or economically unfeasible. Accordingly, in the past, centrifugal compressor wheels for turbochargers have been formed from a unitary casting wherein the blades are cast integrally with a wheel hub. However, a central axial bore is then formed in the cast wheel as by drilling for reception of and installation onto the rotating shaft of a turbocharger or the like, all in a well-known manner. To minimize rotational inertia of the compressor wheel and thereby achieve a desired rapid response to transient operating conditions, the cast wheel is normally formed from aluminum or a lightweight aluminum alloy.

However, cast wheels of aluminum or aluminum alloy including the central bore for mounting purposes are susceptible to fatigue failures in response to tensile loading acting in a radial direction as the wheel is rotatably accelerated and decelerated during operation. Such failures occur most frequently in the region of the central bore whereat tensile loading is highest and further wherein the bore itself acts as a major stress riser. Moreover, in a cast wheel, metallurgical imperfections, such as dross, voids, and inclusions, are inherently created and tend to congregate near the central bore to provide additional initiation sites for stress cracks.

The compressor wheel assembly 10 of this invention advantageously avoids formation of any bore or other cavity formed internally within the compressor wheel 12 thereby removing from the wheel the most prominent stress riser and resulting in a substantial increase in wheel fatigue life. The boreless compressor wheel 12 is provided with alternative means in the form of the thrust spacer sleeve 18 for attachment to the rotating shaft 20 of a turbocharger or the like, wherein the sleeve 18 permits such attachment quickly, easily, securely, and in a manner consistent with high production requirements.

More particularly, with reference to FIGURES 1—3, the compressor wheel assembly 10 comprises the compressor wheel 12 formed from a relatively low inertia material, such as aluminum or a selected aluminum alloy preferably by a casting process to include the hub 14 blending smoothly in an axial direction between a diametrically enlarged backplate disk 22 at one axial end and a relatively blunt nose 24 at an opposite axial end. The hub 14, which is formed without an internal bore, is cast integrally with the circumferential array of centrifugal impeller blades 16 which project generally therefrom in a radially outward direction with a complex and smoothly curved shape to draw air or the like axially in at the nose end and to discharge that air radially outwardly from the backplate disk 22. The specific blade contouring typically includes a forward blade rake generally adjacent the nose 24 for at least some of the blades 16, as illustrated by arrow 26 in FIG. 1, and at least some backward curvature near the periphery of the backplate disk, as referred to by arrow 28.

The cast boreless compressor wheel 12 is secured to the thrust spacer sleeve 18 which is in turn adapted for connection to the rotating shaft of a turbocharger or the like. More particularly, the thrust spacer sleeve 18 is provided as a cylindrical component formed as by machining from a relatively wear-resistant metal, such as tool steel or the like, and is secured to the base or back side of the wheel backplate disk 22 in a position generally centered on a central axis 30 of the

wheel 12. In this regard, as shown in FIG. 2, the base side of the backplate disk 22 has a generally planar configuration at this stage of manufacture to facilitate attachment of the sleeve 18 to the wheel.

While various attachment techniques are possible, the highly preferred method comprises inertia welding wherein, for example, the compressor wheel 12 is held stationary in a suitable fixture (not shown) while the thrust spacer sleeve 18 is advanced on a rotating tool (also not shown) in the direction of arrow 32 in FIG. 2 into friction contact with the base side of the wheel. The thrust spacer sleeve is rotated in friction contact with the compressor wheel to generate sufficient heat for fusion of the annular interface therebetween. This results in a high quality, substantially uninterrupted welded bond over substantially the entire contact areas between the wheel 12 and the sleeve 18.

After the welding step, the base side of the wheel backplate disk 22 is machined to a desired aerodynamic surface contour and surface finish, as illustrated in FIG. 3, and further to remove any upset or flash material which may have been generated during welding. The thrust spacer sleeve 18 is also machined at its inner and outer diameters for relative concentricity and coaxial centering on the central axis 30 of the compressor wheel 12. In addition, a portion of the inner diameter of the thrust spacer sleeve 18 is internally threaded, as illustrated by arrow 34 in FIG. 3, and one or more relatively shallow annular grooves 36 are formed into the outer diameter of the sleeve.

The thus-formed compressor wheel assembly 10 including the cast compressor wheel 12 and the attached thrust spacer sleeve 18 is installed quickly and easily into a turbocharger or the like. More particularly, as shown in FIG. 4, the thrust spacer sleeve threadably receives a threaded end 38 of the rotatable shaft 20 which terminates generally within a shaft opening 40 in a compressor backplate wall 42 separating a compressor housing 44 encasing the compressor wheel 12 and a so-called center housing 46 which includes a thrust bearing assembly 48 and journal bearings 50 (one of which is illustrated) for rotatably supporting the shaft 20. Conveniently, threaded installation of the wheel assembly 10 onto the shaft 20 is facilitated by forming the wheel nose 24 with a polygonal shape, such as a hexagon, (FIG. 1) or the like for engagement by an appropriate wrench or other suitable tool.

The thrust spacer sleeve 18 is threaded onto the shaft 20 into axially bearing engagement with a shoulder on a thrust collar 52 forming a portion of the thrust bearing assembly 48 and rotatable with the shaft. The sleeve 18 thereby spaces the compressor wheel 12 axially relative to the thrust collar 52. In addition, the sleeve 18 receives seal rings 54 in its outer diameter grooves 38 wherein these seal rings engage the inner diameter surface of the backplate wall shaft opening 40 to prevent lubricant passage from the center housing 46 into the compressor housing 44. In this regard, the thrust spacer sleeve 18 is desirably heat treated to provide a relatively hardened, wear-resistant outer diameter, wherein the heat-treating step is conveniently performed prior to inertia welding of the sleeve to the compressor wheel.

In operation, the compressor wheel 12 is positioned within the compressor housing 44 to draw in air through an inlet 55 and to discharge that air radially outwardly into a volute-shaped compressor chamber 56 in the compressor housing 44. This air movement occurs in response to rotational driving of an exhaust gas turbine (not shown) which drivingly rotates the turbocharger shaft 20 to correspondingly rotate the compressor wheel 12 at a relatively high rotational speed. Importantly, in accordance with the present invention, the compressor wheel 12 does not include any internal bore which would act as a stress riser during rotation whereby the compressor wheel 12 has a substantially prolonged fatigue life in comparison with conventional unitary cast wheels having a central bore. Moreover, the sleeve material has sufficient strength to support the assembly in a stable manner on the rotating shaft 20, and the relative direction of the engaged threads is chosen to prevent the assembly from coming off the shaft during operation. Overall efficiency and flow range of the compressor wheel, however, is not impaired, since the impeller blades 14 are formed from a casting process for optimum aerodynamic blade contour.

Claims

1. A compressor wheel assembly for mounting onto a rotating shaft of a turbocharger or the like comprising a boreless compressor wheel (12) having a boreless hub (14) supporting a circumferentially arranged array of impeller blades (16); and an attachment member (18) mounted on said hub generally at one axial end thereof in a position generally centered on a central axis (30) of said hub, said attachment member including means (34), for example a thread, for attachment to a rotating shaft (20), characterised in that the attachment member comprises a cylindrical thrust spacer sleeve having at least one annular groove (36) formed in its outer diameter surface for a sealing ring (54) for sealing the rotating parts in an opening (40) in a wall (42) separating a compressor housing (44) from a bearing housing (46), and characterised in that the thrust spacer sleeve (18) co-operates with a shoulder constituting a component of a thrust bearing (48) for the rotating parts.

2. A wheel assembly as claimed in Claim 1 in which the wheel is cast, for example of aluminium, aluminium alloy, or other low inertia material.

3. A wheel assembly as claimed in Claim 1 or Claim 2 in which the attachment member has been inertia welded to the compressor wheel.

4. A wheel assembly as claimed in any of the preceding claims in which the boreless hub blends smoothly between a diametrically enlarged back plate disc (22) at one end and a nose (24) of reduced diameter at the other end.

5. A wheel assembly as claimed in any of the preceding claims in which the impeller blades are centrifugal impeller blades and are formed integrally with their hub.

Patentansprüche

1. Verdichterlaufradanordnung zur Befestigung auf einer rotierenden Welle eines Turboladers oder dergl., mit einem bohrungsfreien Verdichterlaufrad (12), das eine bohrungsfreie Nabe (14) besitzt, die in Umfangsrichtung angeordnete Laufradschaufeln (16) aufnimmt, und mit einem Befestigungsbauteil (18), das an einem axialen Ende der Nabe in einer etwa zentrischen Position auf einer zentrischen Achse (30) dieser Nabe befestigt ist und das eine Vorrichtung (34), z.B. ein Gewinde, zur Verbindung mit einer rotierenden Welle (20) aufweist, dadurch gekennzeichnet, daß das Befestigungsbauteil eine zylindrische Druckabstandshülse (18) mit mindestens einer kreisförmigen Nut (36) besitzt, die für die Aufnahme eines Abdichtringes (54) in der äußeren Durchmesserfläche ausgebildet ist, um die rotierenden Teile in einer Öffnung (40) in einer Wand (42) abzudichten, die ein Verdichtergehäuse (44) von einem Lagergehäuse (46) trennt, und daß die Druckabstandshülse (18) mit einer Schulter zusammenwirkt, die ein Bestandteil eines Drucklagers (48) für die rotierenden Teile ist.

2. Anordnung nach Anspruch 1, dadurch gekennzeichnet, daß das Verdichterrad beispielsweise aus Aluminium, Aluminiumlegierung oder einem anderen Material geringer Masse gegossen ist.

3. Anordnung nach Anspruch 1 oder 2, dadurch gekennzeichnet, daß das Befestigungsbauteil mit dem Verdichterrad trägheitsgeschweißt ist.

4. Anordnung nach einem der Ansprüche 1—3, bei der die bohrungsfreie Nabe (14) einen glatten Übergang zwischen einer diametral vergrösserten Trägerplattenscheibe (22) am einen Ende und einer Nase (24) verringerten Durchmessers am anderen Ende aufweist.

5. Anordnung nach einem der Ansprüche 1—4, bei der die Laufradschaufeln Zentrifugallaufradschaufeln sind, die einstückig mit ihrer Nabe ausgebildet sind.

Revendications

1. Assemblage de roue de compresseur pour le montage sur un arbre rotatif d'un turbocompresseur de suralimentation ou analogue, comprenant une roue de compresseur sans alésage (12) qui possède un moyeu sans alésage (14) supportant une série circonférentiellement agencée d'aubes d'impulseur (16); et un élément de fixation (18) monté sur ledit moyeu sensiblement à une extrémité axiale de celui-ci, dans une position sensiblement centrée sur un axe principal (30) dudit moyeu, ledit élément de fixation comprenant des moyens (34), par exemple un filetage, pour l'accouplement à un arbre rotatif (20), caractérisé en ce que l'élément de fixation comprend un manchon cylindrique d'espacement et de butée comportant au moins une gorge annulaire (36) ménagée dans sa surface cylindrique extérieure pour recevoir un anneau (54) pour l'étanchéité des partie tournantes dans un orifice (40) prévu dans une paroi (42) séparant un carter de compresseur (44) d'un carter de palier (46), et caractérisé en ce que le manchon (18) d'espacement et de poussée coopère avec un épaulement constituant un composant d'un palier de butée (48) pour les parties tournantes.

2. Assemblage de roue suivant la revendication 1, dans lequel la roue est coulée, par exemple en aluminium, alliage d'aluminium, ou autre matière de faible inertie.

3. Assemblage de roue suivant la revendication 1 et la revendication 2, dans lequel l'élément de fixation a été soudé par inertie à la roue de compresseur.

4. Assemblage de roue suivant l'une quelconque des revendications précédentes, dans lequel le moyeu sans alésage se raccorde progressivement entre un disque arrière plat de plus grand diamètre (22), à une extrémité, et un nez (24) de diamètre réduit, à l'autre extrémité.

5. Assemblage de roue suivant l'une quelconque des revendications précédentes, dans lequel les aubes d'impulseur sont des aubes d'impulseur centrifuge et sont formées de manière monobloc avec leur moyeu.

Fig. 1

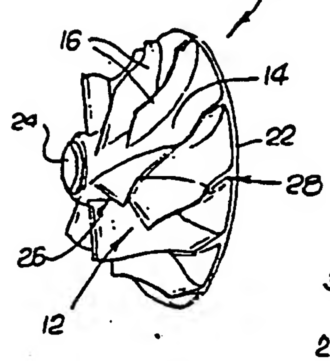

Fig. 3

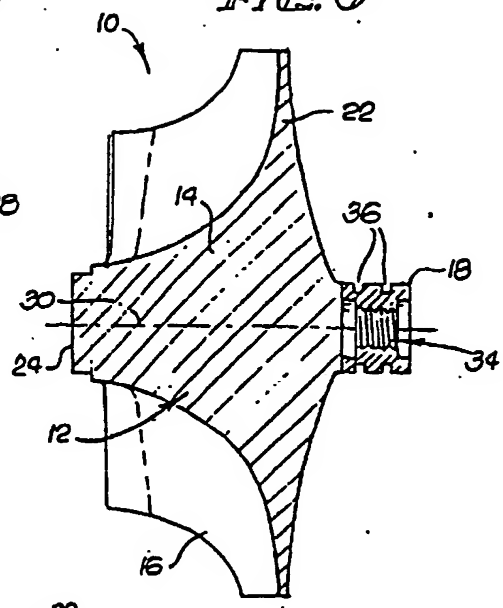

Fig. 2

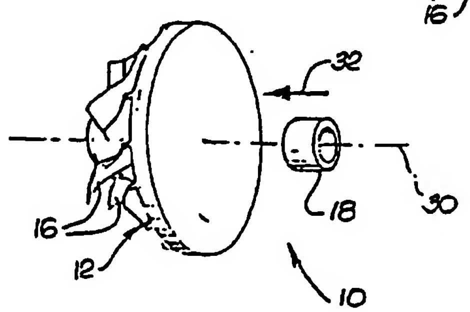

Fig. 9